

## NATO Initiatives to Improve Life Cycle Costing

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### ABSTRACT

*There is a long and documented history of both cost growth and estimating optimism within military programmes. This is particularly the case for multi-national programmes. The NATO ALP-10 –Guidance on Integrated Logistics Support for multi-national equipment projects (ILS) dated June 1990 (Reference [1]) states the following: Multi-national equipment projects will be required to implement a life cycle cost programme. The purpose of this programme is to ensure that the developed system will have the lowest possible life cycle cost consistent with performance and schedule requirements.*

*The results of life cycle costing must, whatever the phase of the programme, contribute to the process by which managers can make the best decisions on options presented to them.*

*The process of generating realistic cost estimates is based on the application of appropriate methods and models. It is essential that future NATO programmes have a framework within which to start generating realistic and consistent life cycle cost estimates.*

*The objective of this paper is to present the findings to date of NATO RTO SAS studies to develop this framework. The first step in this framework was to develop the generic life cycle cost breakdown structure under NATO RTO SAS-028. The next step was to define methods and models within this framework and to develop a guideline for Life Cycle Costing which is the subject of NATO RTO SAS-054. The succeeding working group NATO RTO SAS-069 summarized the work of NATO RTO SAS-028 and NATO RTO SAS-054 in a Code of Practice for Life Cycle Costing.*

*The paper is concluded with the next step in the NATO cost improvement process, i.e. to exercise the guideline for example programmes. In this new working group (NATO RTO SAS-076) an independent cost estimate is conducted on three systems to demonstrate proof of concept. The results of these ICEs will be used to improve the guideline and the code of practice.*

### 1. INTRODUCTION

Already in 1999 it was concluded that NATO is lacking a uniform approach on Life Cycle Costs.

Most nations use their own Cost Breakdown Structure (CBS) for national programs. It was also recognised that within NATO studies there was a lack of common definitions and methodologies within the domain of Life Cycle Cost (LCC) analysis.

It is, however, essential that future NATO programmes have a framework that can be applied to generate realistic and consistent life cycle cost estimates.

The objective of this paper is to present the findings to date of NATO RTO SAS studies to develop this framework. The first step in this framework was to develop the generic life cycle cost breakdown structure under NATO RTO SAS-028. The next step was to define methods and models within this framework and to develop a guideline for Life Cycle Costing which was the subject of NATO RTO SAS-054. The succeeding working group NATO RTO SAS-069 summarized the work of NATO RTO SAS-028 and NATO RTO SAS-054 in a Code of Practice for Life Cycle Costing.

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## NATO Initiatives to Improve Life Cycle Costing

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The structure of the paper follows more or less the structure of the code of practice produced by NATO RTO SAS 069 (see ref. [2]). This report summarized the work of NATO RTO SAS-028 and NATO RTO SAS-054 in a Code of Practice for Life Cycle Costing.

In section 2 the definitions are given, section 3 gives a motivation for doing LCC-analysis. Section 4 details the stakeholders who can benefit from the analysis. Section 5 provides when to do a LCC analysis. Section 6 is the main part of this paper and gives an overview of what is required to conduct a LCC analysis. The paper is concluded with the next step in the NATO cost improvement process, i.e. to exercise the guideline for example programmes.

## 2. WHAT IS LIFE CYCLE COSTING?

LCC is used in different ways and the way analysts and decision makers use LCC has necessarily an impact on its definition and thus on the CBS. This aspect includes the classification of costs into several categories (direct, indirect, variable, etc.), the definition of LCC variants (LCC, TOC, COO, WLC) and the use of each one.

More details on the definitions and the glossary of LCC terminology can be found in (ref. [3]).

The following definitions have been developed:

**Linked costs:** Costs that can be associated to the acquisition, operation, support and disposal of the system. Example: system specific training.

**Non linked costs:** Costs that cannot be readily associated to the system. Examples: medical services, ceremonial units, basic general training (not related to a specific equipment), headquarters and staff, academies, recruiters, etc.

**Direct costs:** Costs referring to activities that can easily be allocated to a system or product. Example: Costs for a system specific tool.

**Indirect costs:** Costs referring to activities that can be associated to several systems and cannot easily be distributed between them. Example: Cost for a multi-functional tool.

**Variable costs:** These costs are affected by the existence of the system. They fluctuate with a characteristic of the system. Example: Costs for fuel.

**Fixed costs:** These costs do not vary because of the existence of the system. Example: Costs for infrastructure.

**Life Cycle Cost (LCC)** consists of all direct costs plus indirect-variable costs associated with the procurement, O&S and disposal of the system. Indirect costs may include linked costs such as additional common support equipment, additional administrative personnel and non-linked costs such as new recruiters to recruit additional personnel.

All indirect costs related to activities or resources that are not affected by the introduction of the system are not part of LCC.

LCC comprises the marginal costs (both direct and indirect) of introducing a new equipment or capability. LCC is used as a minimum for the analysis of alternatives; it does not include notional allocation of costs, whereas TOC and WLC might do so.

LCC is used to compare options of alternatives, and often for economic analyses.

**LCC: Life Cycle Costs = direct costs + indirect, variable costs**

**Total Ownership Costs (TOC)** consists of all elements that are part of LCC plus the indirect, fixed, linked costs.

These latter may include items such as common support equipment, common facilities, personnel required for unit command, administration, supervision, operations planning and control, fuel and munitions handling.

TOC represents all costs associated with the ownership of a system except non-linked fixed costs that are related to the running of the organisation.

TOC is used for budgeting purposes, determining the use of services between systems, for optimisation purposes and for financial analysis.

**TOC: Total Ownership Cost = LCC + linked, indirect, fixed costs**

**Whole Life Costing (WLC)** consists of all elements that are part of TOC plus indirect, fixed, non-linked costs. These latter may include items such as family housing, medical services, ceremonial units, basic training, headquarters and staff, academies, recruiters.

In WLC all costs or expenses made by the organisation are attributed to the systems or products they produce.

As WLC represents the total budget provision including such element as headquarters costs, it allows the visibility of the complete allocation of funds.

WLC is used for a strategic view and high level studies.

**WLC: Whole Life Cost = TOC + non linked, indirect, fixed costs**

### **3. WHY DO LIFE CYCLE COSTING?**

The NATO ALP-10 guidance (ref. [1]) states that all multi-national programmes must implement a life cycle cost programme. A life cycle cost estimate, done properly, is the single best metric for measuring the value for money of defence resources. This metric, in turn, is useful in wide range of applications including:

- Evaluating alternative solutions and source selection
- Assessing the affordability of the programme
- Managing existing budgets
- Developing future expenditure profiles
- Evaluating cost reduction opportunities
- Evaluating areas of financial risk and uncertainty.
- Improving the business processes of the organisation.

There are clear and unequivocal benefits to be gained by all the stakeholders through undertaking a life cycle cost analysis on the system of interest. These include:

- Providing a better insight of all the costs in the programme and identifying the key cost drivers for potential cost savings.
- Providing a realistic planning programme and budgeting through a methodical and consistent estimating approach.

- Providing the basis for measurement of effective organisational and logistic scenarios and provisions.
- Providing a measure to evaluate two or more technically different solutions to assist the decision making process.

### 4. WHO CAN BENEFIT FROM LIFE CYCLE COSTING?

Life cycle costing is a very useful process to support the control and management of all the mandatory and stakeholders' multi-criteria requirements in the most effective and economical way.

The stakeholders in the life cycle are those who have a justifiable claim to be allowed to influence requirements which defines the system of interest. These include, but are not limited to:

- Those affected by the system of interest, such as clients and suppliers;
- Project and programme managers who are concerned for the system of interest to succeed;
- Regulators such as defence decision makers, local and state governments and standardisation bodies;
- Those involved in the development, acquisition and support organisation such as engineers, architects, planners and financial personnel.

### 5. WHEN TO CONDUCT LIFE CYCLE COSTING?

The approach taken to conduct life cycle costing is highly dependent on the life cycle stage of the system of interest as this determines the availability of data and the technical maturity of the system.

NATO, through the AAP-48 Life Cycle Stages and Processes (ref. [4]), has adopted ISO 15288 System Engineering – System Life Cycle Process (ref. [5]) for dividing the life cycle stages, as presented in Figure 1.

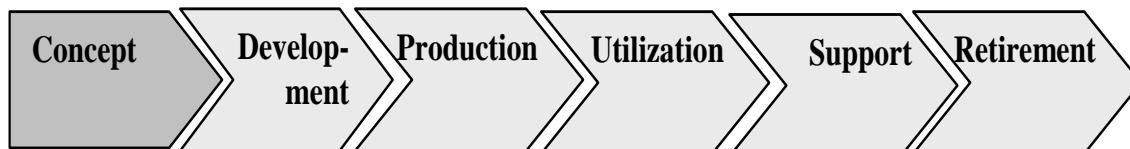


Figure 1: Life Cycle Stages

Each stage requires a different approach in conducting Life Cycle Costing.

**Concept Stage** The concept stage starts after the decision to fill a capability gap with a materiel solution and ends with the requirements specification for this materiel solution.

**Development Stage** The development stage is executed to develop a system of interest that meets the user requirements and can be produced, tested, evaluated, operated, supported and retired.

**Production Stage** The production stage is executed to produce or manufacture the product, to test the product and to produce related supporting and enabling systems as needed.

**Utilisation Stage** The utilisation stage is executed to operate the product at the intended operational sites, to deliver the required services with continued operational and cost effectiveness.

**Support Stage** The support stage is executed to provide logistics, maintenance, and support services that enable the continued system of interest in operational and sustainable service. The support stage is completed with the retirement of the system of interest and termination of support services.

**Retirement Stage** The retirement stage provides for the removal of a system of interest and related operational and support services and to operate and support the retirement system itself. This stage begins when a system of interest is taken out of service.

Life Cycle Cost analysis should be applied as early as possible in the life cycle of the system of interest, as the greatest opportunities to reduce life cycle costs usually occur during the early phases of the programme (as shown in Figure 2).

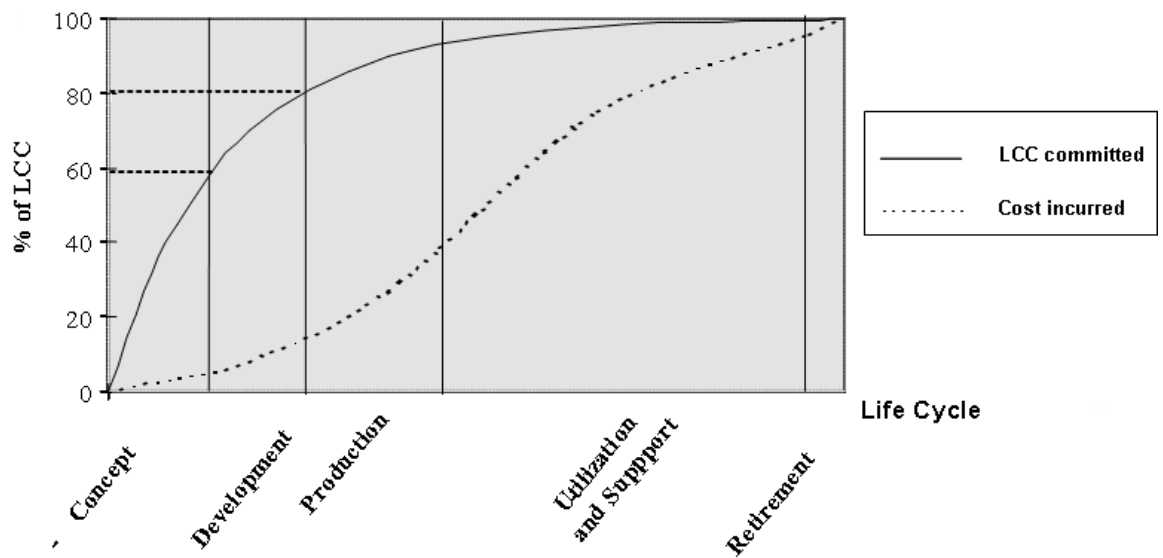


Figure 2: Traditional LCC committed versus incurred cost curve

## 6 WHAT IS REQUIRED TO CONDUCT LIFE CYCLE COSTING?

Before a life cycle cost can start many factors have to be determined as they have influence on the way a Life Cycle Cost analysis can be conducted. These factors include: the objective, requirements, constraints and the assumptions are discussed below. Furthermore, the CBS, methods and models to estimate costs were reviewed and issues related to data collection, uncertainty and risk, reporting and presentation and multi national aspects were discussed. Furthermore for all these topics recommendations were provided.

### 6.1 Objective

Prior to any costing activity it is essential to define what is to be estimated and understand what the estimates will be used for (e.g. setting budgets, options evaluation, pricing, etc).

The system of interest could range from a large turnkey project (e.g. a major capital investment), a stand-alone system (e.g. individual platforms such as a ship, aircraft or tank) to a worldwide application (e.g. theatre(s) of operation and use). The approach to be adopted needs to be tailored to suit the questions to be answered, the costing requirements and the availability of suitable data. With some variation (to the level of detail), the same basic approach to life cycle costing can be applied to all projects regardless of their specifications.

### 6.2 Requirements

A requirement is a singular documented need of what a particular product or service should be or do. It is a statement that identifies a necessary attribute, capability, characteristic, or quality of a system in order for it to have value and utility to a user.

A clear understanding of the requirements, which is a statement of needs, relating to the system of interest is essential to conduct life cycle costing.

There are three main categories of requirements and each one of them represents a specific area of the stakeholder's and user's interest for the new system of interest:

- Operational requirements are a set of information representing all identified needs of the stakeholder, in order to fill an existing operational gap.
- Technical requirements are the information deriving from the translation of the stakeholder operational requirements into a set of measurable technical specifications of the new system of interest.
- Performance requirements represent the services that the new system of interest should provide to the user, according to the stakeholder requirements.

Analysing the stakeholder requirements is called the Requirements Analysis Process and is performed during the Conceptual Stage of the Life Cycle Stages ISO 15288 (ref. [5]).

In order to define the Stakeholder requirements, the steps of the Stakeholder Requirements Definition Process, as described in AAP-48 (ref. [4]) must be followed.

Once the requirements are defined then the estimation of the life cycle cost of the system of interest can begin.

### 6.3 Identification of constraints

The identification of the constraints is required as they will influence the life cycle costing process. There are two types of constraints.

**External constraints:** Though the benefits of life cycle costing are recognised, the approach for its use and implementation could vary from Nation to Nation, due to:

- Time constraints imposed by decision makers.
- Potential high number of organisations involved.
- Limited and suitable resources to support life cycle costing.

**Internal constraints:** These constraints are inherent to:

- Data availability
- Limited and suitable resources to conduct life cycle costing
- Maturity of requirements definition

## **6.4 Assumptions**

The lack of information (e.g. data related to an operational scenario, system life and support organisation) of any kind or in any stage makes it necessary to identify and record assumptions in order to develop a complete life cycle cost of the system of interest.

In order to maintain an appropriate audit trail it is necessary to record and document all changes to data and assumptions during the estimating process.

It is good practice to undertake a sensitivity or “what if” analysis on key assumptions. An example would be to examine how maintenance costs would vary with different values of system reliability.

## **6.5 Cost Breakdown Structure**

A Cost Breakdown Structure (CBS) is used to ensure that all relevant cost elements related to the system of interest are identified, defined and will be considered. This may be defined as an organised list of all cost items related to the life cycle of a system or programme.

### **6.5.1 Definition**

A CBS must satisfy some requirements such as:

- Being easy to develop, use and update;
- Sufficiently comprehensive to include all relevant cost items;
- Being clear in terms of cost definitions;
- Be flexible in order to be adapted to different systems;
- Comparable to other cost breakdown structures enabling decision makers to make option analyses.

Life Cycle Cost can be broken down in a number of ways. Examples of breakdowns are:

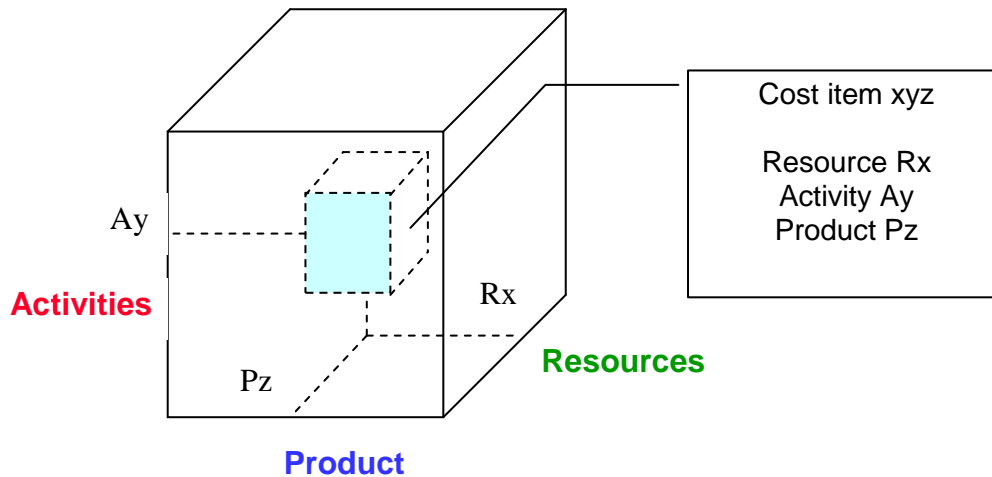
- By time (year, month, or life cycle stage)
- By type of costs (direct, indirect, linked, variable or fixed)
- By product (systems, subsystems, components)
- By process/activity (management, engineering, maintenance etc.)
- By resources (personnel, equipment, consumables)
- By organisation:
  - unit, service branch, etc.
  - nation (multinational programme)
  - public/private company

Most of these breakdowns are not mutually exclusive, and a CBS will typically involve a combination of a number of these types of breakdowns.

In the NATO RTO SAS-028 report (ref. [3]) is suggested to break the cost down by “resource” used by an “activity” applied to a “product”.

- The product tree defines all relevant product elements during the life of a system.
- The activity list defines all possible activities performed during the life of a system.
- The resource list defines all possible resources used by the activities.

The list of all cost elements is then obtained by combining the product tree, the activity list and the resource list. This is illustrated in figure 3.



Cost of **consumables** for the **maintenance** of an **aircraft**

Cost of **personnel** for the **development** of a **software**

**Figure 3: Cost Breakdown Structure**

### 6.5.2 Review

The NATO generic cost breakdown structure developed by NATO RTO SAS-028 (ref. [3]) has been reviewed by nations and organisations participating in RTO SAS-054. This Task Group recommended in their report (ref. [6]) some changes to the NATO generic cost breakdown structure based on recent OCCAR experience in implementing it on multi-national programmes.

### 6.5.3 Recommendations

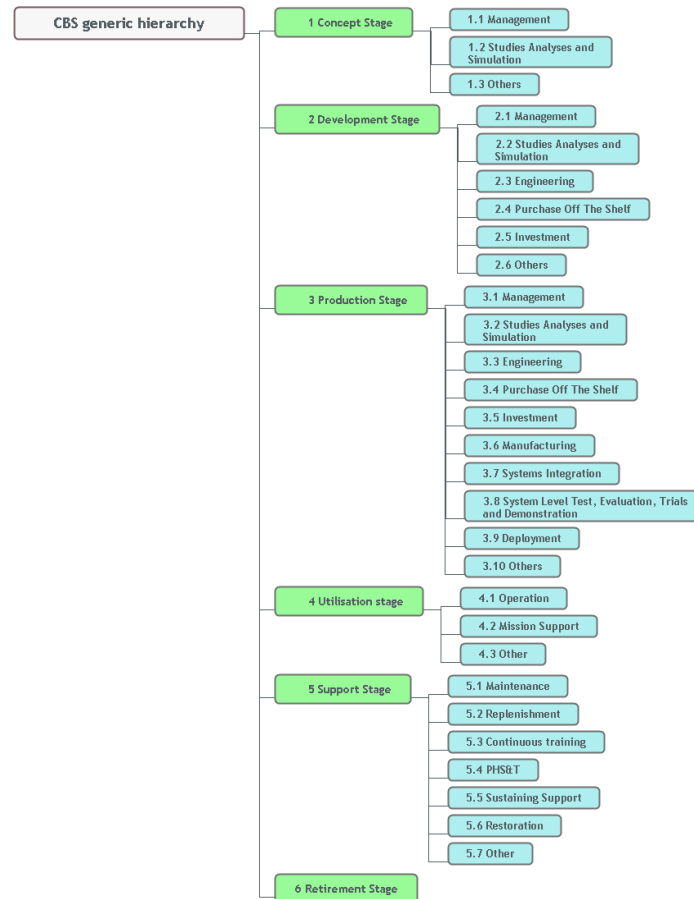
Enhancements to the GCBS (generic cost breakdown structure) to improve its use

- It has been found that most nations have not adopted the generic cost breakdown structure reported by SAS-028 (ref. [3]) as their national life cycle cost breakdown structure. However, the NATO generic cost breakdown structure has been applied on specific multi-national programmes and some areas of enhancement are recommended.

The structure does not allow the identification of the life cycle cost results over the time phasing for national financial and programme contributions. Therefore, it is recommended to include two dimensions in addition to the Activity, Product and Resource dimensions. These additional dimensions are:

- Time phasing
- National contribution

- The coding of the Generic Cost Breakdown is complex for non-experts. So it is recommended to adopt a Generic Hierarchy for the GCBS as provided in figure 4. This gives an instant overview of a CBS, based on stages and activities. For large, complex and very detailed CBS structures, however, it is recommended to assign a numeric order code to each cost element in the CBS.



**Figure 4: CBS Generic hierarchy**

## 6.6 Data

Data is required in order to conduct a life cycle cost analysis. In terms of time, effort, and resources consumed, collection of data is a major part of a life cycle cost study. Life cycle costing is a data driven process, as the amount, quality and other characteristics of the available data often define what methods and models can be applied, what analyses can be performed, and therefore determine the usefulness of the results that can be achieved.

### 6.6.1 Review

The amount and quality of data available often increases in time with the maturity of the system of interest, and the level of assumptions decreases. As more data becomes available less assumptions have to be made, and more detailed methods can be used to estimate costs. Unfortunately, because uncertainty, risks, and opportunities decrease as the life cycle progresses, the need for knowledge is greatest at the earliest stages. This means that more time and resources should be allocated to the data collection effort during the earlier stages of the life cycle in order to develop an acceptable and auditable life cycle cost estimate.

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Figure 5 illustrates the relationship between data maturity and level of assumptions to be applied.

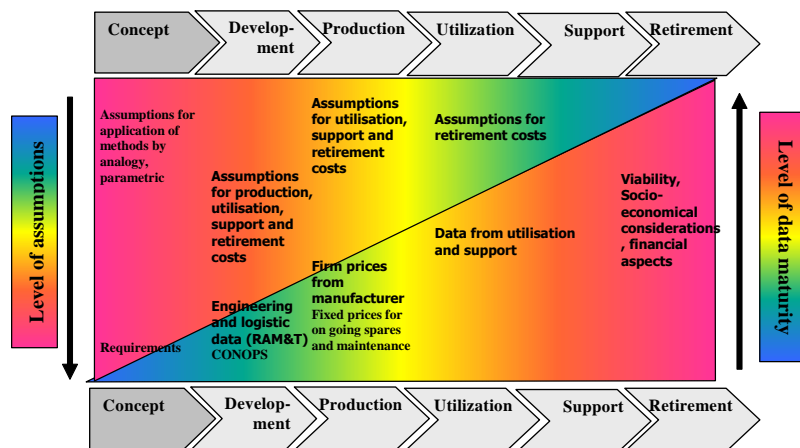


Figure 5: Relation level of data maturity and level of assumptions

### 6.6.2 Data Sources

Life cycle costing requires a wide variety of data and these must be collected from an even wider variety of sources. When preparing a cost estimate, analysts should consider all credible data sources. A distinction can be made between internal and external data.

**Internal data** can be defined as data generated internal to the programme.

**External data** is provided by a data source outside the programme. External data sources can be industry or other military branches or other organisations.

In order to collect data from external sources cost estimators and the programme managers may use templates for a life cycle cost questionnaires as part of an Invitation to Tender, Request for Information, Request for Quotation or Request for Proposal.

### 6.6.3 Data Normalisation

Raw data for life cycle costing originates from a variety of sources. There is generally a lack of uniformity in the data and therefore a certain amount of normalisation is unavoidable. Generally, data normalisation covers changes and adaptations to make it applicable for use in a cost model. The main areas of data normalisation include:

- Adjusting all data to a Base Year. This will facilitate the analysis of the financial data on a comparative basis.
- Appropriation of constant and current year cost data to account for anticipated inflation.
- Selection of correct indices for conversion.
- Selection of correct exchange rates.
- Adjusting costs and/or data for technical specifications such as size, weight, complexity, maturity, etc.
- Adjusting costs and/or data or performance data for different operating profiles, temperatures, mileage, etc

- Adjusting prices for lot sizes, learning curves, producer capability, etc

## 6.6.4 Recommendations

Investments should be made to increase the accuracy, visibility, and availability of cost, programmatic, technical, and performance data within the NATO/PfP cost analysis community.

- Data collection forms a large part of the life cycle costing activity and significant effort is expended to gather and analyse the data so that it is suitable for use in life cycle cost analysis studies. Improvements in data exchange standards or even the development of a NATO costing database would:
  - (a) Improve the quality of the life cycle cost estimate.
  - (b) Reduce the effort needed to conduct the life cycle cost estimate.
  - (c) Reduce the time schedule to conduct the life cycle cost estimate.

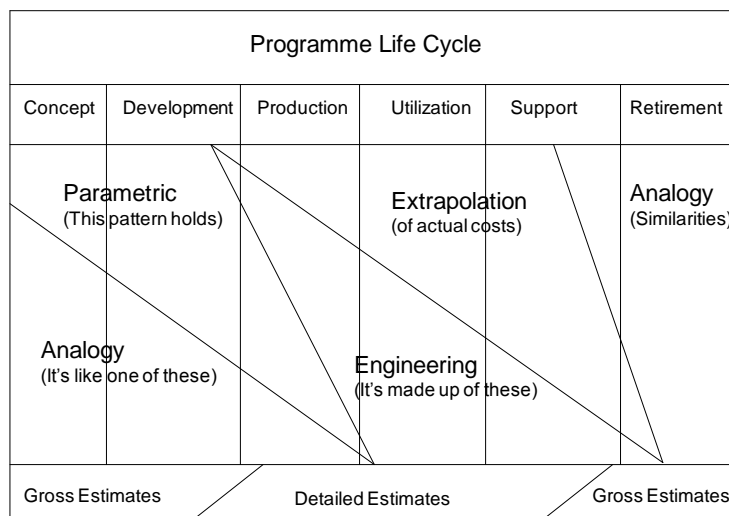
## 6.7 Methods

There are many methods available to conduct life cycle cost estimates. It is important to understand the applicability and boundaries of each method in order to use them appropriately.

### 6.7.1 Review

The SAS-054 report (ref. [6]) has captured all the key estimating methods and provided examples to demonstrate their applicability. For consistency, both the methods and models have been categorised as Optimisation, Simulation, Estimation and Decision Support. The findings confirmed that almost all nations used a similar process to develop life cycle cost estimates; that the quality of the available data nearly always determined the method to be employed; and, in addition, that the type of study also influenced the process and the selection of the appropriate method.

Figure 6 shows an example of the most common application of methods in each stage of the programme life cycle. A more detailed overview of appropriate methods can be found in the report of NATO RTO SAS-054 (ref. [6]).



**Figure 6: Cost Estimating Methods**

### **6.7.2 Recommendations**

Life cycle cost estimates should be fully documented.

- A cost analyst should be able to re-create the complete estimate working from the documentation alone.
- All assumptions and data related to the study should be captured in an Master Data and Assumptions List (MDAL) or Cost Analysis Requirements Document (CARD) or similar document.
- Assumptions recorded in an assumptions list such as the MDAL or CARD should be questioned by an independent technical team.

All life cycle cost estimates should be prepared by suitably experienced personnel.

- Decisions such as budget setting and options analysis studies are often conducted when data to support cost forecasting and life cycle costing is very sparse. It is therefore essential that experienced personnel is used to conduct the life cycle cost estimates to support the decision process at these key stages.

The life cycle cost analysis should include an affordability analysis

- Affordability plays an important part in programme decisions throughout the life cycle. Even before a programme is formally approved for initiation, affordability plays a key role in the identification of capability needs. This aspect is part of the process which balances cost versus performance and in establishing key performance parameters. Although this is not common practice in all nations the assessment of affordability is one that we recommend should be conducted by all nations.

Life cycle cost estimates, where possible, should use two or more independent methods for each cost breakdown structure element

- The use of two or more independent methods to develop the life cycle cost estimates will improve the confidence in the results and help to validate the outputs. It is accepted that this may be tempered by the constraints imposed by a financial threshold or by a simple consideration of what the estimate will be used for (e.g., rough cost for initial views or detailed costs for decision making). So, the use of alternative methods should always be evaluated from a cost-benefit point of view.

## **6.8 Models**

A Cost Model is a set of mathematical and/or statistical relationships arranged in a systematic sequence to formulate a cost methodology in which outputs, namely cost estimates, are derived from inputs. These inputs comprise a series of equations, ground rules, assumptions, relationships, constants, and variables, which describe and define the situation or condition being studied. Cost models can vary from a simple one- formula model to an extremely complex model that involves hundreds or even thousands of calculations. A cost model is therefore an abstraction of reality, which can be the whole or part of a life cycle cost.

There are many models available to conduct life cycle cost estimates. It is important to understand the applicability and boundaries of each model in order to use them appropriately.

### **6.8.1 Review**

The NATO RTO SAS-054 report (ref. [6]) showed that in developing life cycle cost estimates all the nations have in-house developed models that are based on a defined Cost Breakdown Structure. Data for these models is estimated either by empiric methods or parametric formulae (for completeness, sometimes both techniques are employed). The findings confirmed that there were many life cycle cost models in use and these are identified within the report. Generally speaking, the use of more than one model to produce a life cycle cost estimate is considered good practice. This would provide verification of the life cycle cost estimate. However, the use of multiple methods and models should always be balanced with the

knowledge and understanding of how the estimate will be used. It is important to ensure that the life cycle costing activities are conducted in a cost-effective manner and balanced with what is realistically achievable at a specific stage in the programme. It is also important to ensure that every model used for acquisition and life cycle costing is subject to calibration, verification and validation. This will build confidence that the cost model is fit for purpose.

### **6.8.2 Recommendations**

All life cycle cost models should be validated

- It is essential that all life cycle cost models implemented through spreadsheets or more advanced programming techniques be validated by using recognised testing processes. This will increase confidence that the model is fit for purpose and that the input data and results can be assessed through a clear audit trail and mathematical reasoning of any cost estimating relationships.

## **6.9 Uncertainty and Risk**

Life cycle cost estimates of any new system of interest will inevitably contain uncertainty and risk. The definition of each term is given as:

- **Uncertainty** is the variance associated with the data and assumptions.
- **Risk** is the consideration of potential adverse events and has two components (1) the probability of occurrence of an unfavourable event, and (2) the consequences of that event.

### **6.9.1 Review**

Estimates are often made when information and data is sparse. Estimates, in turn, are based on historical samples of data that are almost always messy, of limited size, and difficult and costly to obtain. And no matter what estimation tool or method is used, historical observations never perfectly fit a smooth line or surface but instead fall above and below an estimated value. To complicate matters, the weapon system under study is often of sketchy design.

For all of these reasons, a life cycle cost estimate, when expressed as a single number, is merely one outcome or observation in a probability distribution of costs. To better support the decision making process it is recommended that three point estimating is always undertaken. A wide variety of methods and models available for conducting risk and uncertainty analysis of life cycle cost estimates of weapons systems have been. Each, if used properly, can give scientifically sound results and provide a better yardstick for an accurate life cycle cost estimate.

Conducting risk and uncertainty analysis on life cycle cost estimates of the systems of interest is required to fully understand the possible variances in programme estimates in terms of cost.

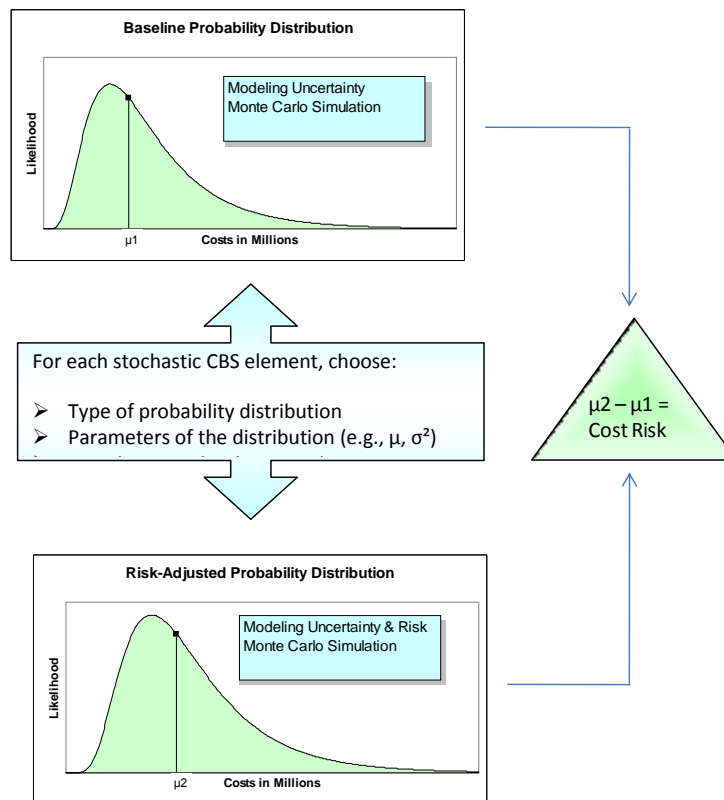
### **6.9.2 Recommendations**

The results of a life cycle cost estimate should be shown as a three point range of estimates

- A life cycle cost estimate is not a single number but rather a continuum or distribution of possible values.

Risk and uncertainty analysis should be conducted following the principle for estimating risk and uncertainty as given in figure 7

- By using this process for the estimation of risk and uncertainty, decision makers can budget a programme at a specific cumulative percentage level of risk and they will be able to know the financial impact of specific risk events.



**Figure 7: Principles of estimating risk and uncertainty**

Risk and uncertainty analysis should be conducted at the same time as the life cycle cost estimate

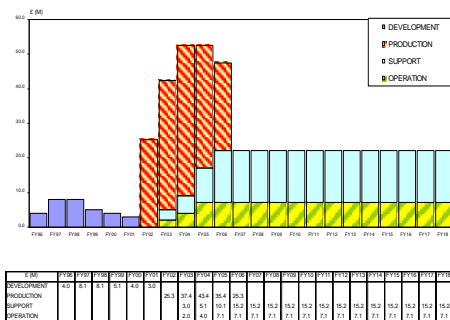
- To better support senior leadership, some sense of risk and uncertainty needs to be presented at the same time as developing the point estimate. This will present the decision maker with a comprehensive true view of the programme's likely eventual outcome.

## 6.10 Presentation & Reporting

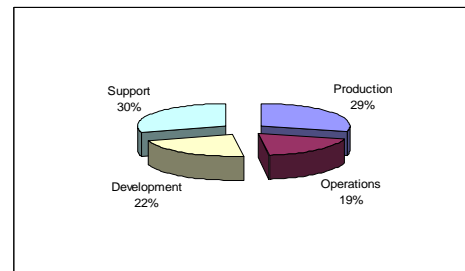
The results of cost studies are very important, as they should provide the stakeholders with an answer to their question. It is therefore very important that the results should be presented and reported in a manner that the stakeholders can easily understand.

Results can be presented in a wide range of tabular and graphical forms. The favour is to include graphical presentations of the results wherever possible. This enables the widest possible audience to have a clear picture of the overall results while retaining the detailed tabular presentations for those that require them.

Two typical forms of graphical presentation (the spend profile and cost allocation pie chart) are shown in figure 8 and 9. These figures indicate costs at a high level but can also be used to present a more detailed level as required. For presentation purposes these costs have been truncated at Financial Year (FY) 18.



**Figure 8: Example of a Baseline Life Cycle Cost Spend Profile**



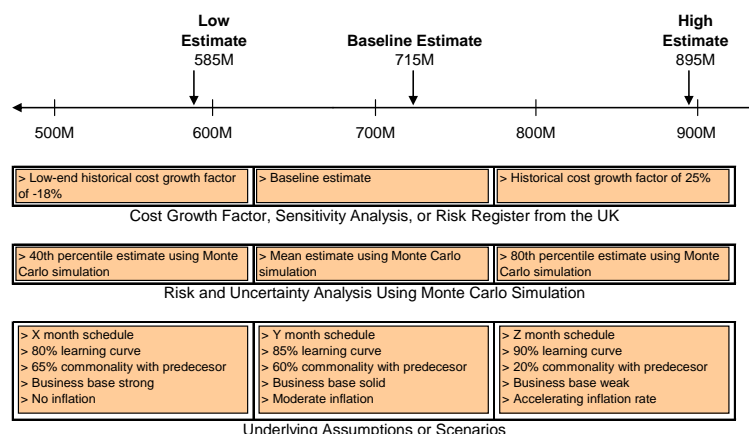
**Figure 9: Example of a Life Cycle Cost Allocation**

**NOTE:** The cost allocation percentage shown in this example should not be considered as being representative of all life cycle cost estimates.

The output of the life cycle cost study should be a report incorporating the results and conclusions as well as a presentation on the basis of those results. It should include a full definition of the aims and conduct of the study, the definitions of the options studied, the costing boundary considered and the assumptions underlying the cost elements.

The figures 8 and 9 represent single point estimates with no consideration to the presentation of uncertainty and risk. Figure 10 presents a recommended approach for communicating results of a life cycle cost estimate to senior decision makers (see ref. [7]).

The top line shows a three point range of estimates, and conveys the idea that a cost estimate is not a single number but rather a continuum or distribution of possible values.



**Figure 10: Recommended Presentation of Cost Estimating Risk Analysis**

The top two shaded bars of the figure show the results of a historical trend analysis on similar programmes and the results obtained from the risk and uncertainty analysis reported at a given percentile. The bottom shaded section, which should always be included in the presentation of the estimate, shows the key assumptions or scenarios associated with the low, baseline, and high estimates.

This approach will lead to the establishment of a sound, well-structured methodology for the conduct of and presentation of life cycle cost estimates.

## **6.11 Multi-National Programmes**

Multi-national programmes involve at least two nations who have agreed upon the main principles of co-operation in a Memorandum of Understanding, or an equivalent arrangement, for one or several phases of the entire lifetime of that programme.

### **6.11.1 Review**

The life cycle cost studies for multi-national programmes follow the same principles as national life cycle cost requirements. However, there are some specifics that have to be taken into account in terms of organisation, currency issues, studies, model(s) and presentation of the life cycle cost results.

A significant added value of a multi-national programme is the possibility to achieve savings by common procurement and support. Therefore the scope of the multi-national life cycle cost studies could be focused on the evaluation of alternatives linked to the development of commonalities.

The basic principle for multi-national life cycle cost estimates is the definition of a common framework managed centrally by the entity in charge of the management of the Programme. This entity could be a Pilot Nation or an International Programme Office or a NATO Agency.

### **6.11.2 Recommendations**

For multi-national programmes the participating nations should agree on a common LCC framework

- It is essential that all parties in a multi-national programme agree on a common life cycle cost framework. This framework is determined by the costing boundary and the tools that will be employed to populate the framework. A common framework will provide consistency, comprehensiveness, traceability and audit. All are essential to achieve life cycle cost estimates in a timely and responsive manner.

## **7 NEXT STEPS**

The next step in developing a framework for generating realistic and consistent life cycle cost estimates is to demonstrate the proof of concept (methods and models) by using a practical application of the guideline.

In a new Task Group (NATO RTO SAS-076) an independent cost estimate is currently conducted on three systems to demonstrate proof of concept. This Task Group started in 2008 and expects to produce the final report early 2011.

Independent cost estimates are developed for the following systems:

- Landing Platform Docks (LPDs) for the Royal Netherlands Navy
  - HMS Rotterdam
  - HMS Johan de Witt
- NATO Alliance Ground Surveillance System (AGS)
- Canada's Light Armored Vehicle III

The results of these ICEs will provide invaluable feedback on the accuracy and completeness of the guideline will be used to improve the guideline and the code of practice.

### **7.1 Netherlands LPDs**

For the Netherlands LPDs both an ex-post testing and an ex-ante estimation is applied.

#### **Ex-post testing**

For the Netherlands LPDs an independent cost estimate is produced, based on the SAS-054 guidelines for best practice, using the Data Assumption Description Document (DADD) (comparable with CARD or MDAL) at a specific point in time. Historical data from 55 ships in classes is gathered and the R&D an investment cost will be estimated by using these data. From the Royal Netherlands Navy LPD programme office true costs are obtained. During the study, risks and uncertainty will be analyzed, and costs generated over the life cycle. Finally, after the ICE is completed, the task group will compare the results of the ICE with the actual acquisition cost of the weapon system under study. These actual costs might include those for development or first unit production. Differences between actuals and estimates will be calculated and analyzed.

#### **Ex ante estimation**

An ex-ante estimate will be produced for the Operation and Support (O&S) costs using the operational profile of the ships and descriptive parameters. This estimate will be compared with actual budgets and budget forecasts for the Netherlands LPDs

### **7.2 NATO AGS**

#### **Ex ante estimation**

For the NATO AGS an ex ante estimation will be produced to support NATO and national decision making. A estimate will be produced for the R&D and Production costs of the Global Hawk using technical parameters of the system. These results will be compared with cost information in General Accounting Office report related to Unmanned Aerial Vehicles. In order to estimate the costs of the sensor and the associated ground stations a Parametric Model will be used.

### **7.3 Canada LAV III**

#### **Ex-post testing**

For the Canadian LAV an ex post estimation will be produced by gathering Canadian program actual cash flows and acquisition numbers per year. These actual costs will be compared with estimated concept stage and development stage total costs. The actual costs will also be compared with historical calculated acquisition cost per year. O&S costs will be calculated using average usage per year.

## **8 CONCLUSIONS**

This paper presents the findings to date of NATO RTO SAS studies to develop a framework for Life Cycle Cost analysis in a multi national environment. The first step in this framework was to develop the generic life cycle cost breakdown structure under NATO RTO SAS-028. The next step was to define methods and models within this framework and to develop a guideline for Life Cycle Costing which is the subject of NATO RTO SAS-054. The succeeding working group NATO RTO SAS-069 summarized the work of NATO RTO SAS-028 and NATO RTO SAS-054 in a Code of Practice for Life Cycle Costing

The paper is concluded with the next step in the NATO cost improvement process, i.e. to exercise the guideline for example programmes. In this new working group (NATO RTO SAS-076) an independent cost estimate is conducted on three systems to demonstrate proof of concept. The results of these ICEs will be used to improve the guideline and the code of practice.

## **9 REFERENCES**

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